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Response of barley to nano-feeding with seaweed extract and bio-fertilizer

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During the 2020–2021 growing season, a field experiment was carried out in a farmer's fields in Al-Khader District (30 km south of Al-Muthanna Governorate). To know effect of nano-feeding by seaweed extract with three concentrations (0, 0.5, 1 ml l^{-1}) and bio-fertilizer in three concentrations (0, 2.5, 5 g l^{-1}) in the yield and its components of barley crop. The experiment was applied according to (R.C.B.D) a randomized complete block design with three replications. As the seaweed extract concentrations were placed in main plots and bio-fertilizer was placed in the sub-plots, the following was discovered: The results showed the superiority of spraying with a concentration of 1 ml l^{-1} of seaweed extract, it gave the highest averages for spikes number of m^2, grains number per spike, and total grain yield amounted to 412.60 spikes m^2, 45.36 grains $spike^{-1}$, and 4253 kg ha^{-1}, compared to the no-spray treatment, and no differences were shown. Significance between spraying and non-spraying in 1000 grains weight. Significantly superior was spraying of bio-fertilizer at a concentration of 5 g l^{-1} in spikes number of m^2, grains number per spike, and grain yield; it increased by an increased rate of (14.45%, 22.63% and 20.00%) over the control treatment for traits in succession, while the non-spraying treatment was significantly superior on the rest of treatments in description of weight 1000 grains, it gave the highest mean of 34.62 g. As for the interaction, the results showed a significant difference in characteristics; grains number per spike, 1000 grains weight, and total grain yield. The combination (1 ml l^{-1} of seaweed extract x 5 g l^{-1} of bio-fertilizer) gave a highest grain yield at 4589 kg ha^{-1} compared compared to the remaining combinations.

Keywords: Barley crop; *Hordeum vulgare* L.; seaweed extract; bio-fertilizer.

INTRODUCTION

The barley crop is one of the oldest crops known to man, and the ancient world used to cross it as the main source of bread. Its grains contain proteins, vitamins, and amino acids that are important in human nutrition, as well as good levels of fiber and selenium (Gani and Salman 2011). Barley ranks second in Iraq regarding cultivated area and production, as the cultivated area for the (2020) season amounted to about 4,528 thousand dun., with an average production of 387.8 kg dun-1 (Central Bureau of Statistics, 2020).

Nanotechnology is of importance in the agricultural aspect because of its tools that contribute to solving some issues related to food security through the development of technology used in the field of agriculture, which leads increase soil fertility and production capacity, as well as an improvement in fertilizer effectiveness and a reduction in their financial costs (Al-Ramadi *et al.*, 2016; Al-khaldy *et al.*, 2022).

Because of the important role of bio-fertilization and seaweed extracts in the plant, Especially with the current worldwide shift away from using chemical fertilizers because of the health and environmental harms they cause, in addition to using non-chemical options to conventional fertilizers, which are characterized by their non-toxicity, low cost, and no harm, so it is recommended to use organic fertilizers as alternatives to fertilizers Chemical (Zodape *et al.*, 2010). For their high concentrations of beneficial micro- and macronutrients and growth regulators, seaweed extracts are a popular nutrient choice. Adding them to plants contributes to increasing the absorption capacity of the roots, which leads to increased vegetative growth and thus reflects positively on improving and increasing productivity (Jensen, 2004). Bio-fertilization is also important for increasing production and improving

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quality through the biological activity of materials produced with bio-fertilizers, such as amino acids, growth regulators, enzymes, and vitamins, which contributes to increased plant growth (Abdel-Mawgoud *et al.*, 2011). This research might be used to demonstrate that applied sciences are extremely important in life due to their numerous applications in the present and past (Alhasany *et al.*, 2019 ; Altai, *et al.*, 2020; Al-Hasany *et al.*, 2020; Abido *et al.*, 2021)

It was hypothesized that nano-feeding with bio-fertilizer and seaweed extract would increase barley crop yields, thus researchers set out to test this hypothesis.

MATERIALS AND METHODS

During the 2020–2021 growing season, a field experiment was carried out in a farmer's fields in Al-Khader District (30 km south of Al-Muthanna Governorate), to know the effect of nano-feeding with seaweed extract and bio-fertilizer on the yield and its components of barley crop. The randomized complete block design (RCBD) was used for the experiment with three replications, with a split-plot arrangement. As the concentrations of seaweed extract occupied the main plots, which are (0, 0.5, 1 ml l^{-1}) symbolized by (E0, E1, E2), respectively, while the bio-fertilizer occupied the sub-plots with three concentrations (0, 2.5, 5 g l^{-1}) symbolized it with the symbol (F0, F1, F2) on the sequence.

Tasks related to soil and crop maintenance were performed., such as plowing, smoothing, and leveling, after which seeds were sown on (01.11.2018) of the Samir cultivar (Al-Qaisi, 2005) with 120 kg of seed per hectare (Al-Farih *et al.*, 2015). The field was partitioned based on the design chosen, into an experimental unit consisting of an area (2 x 2 = 4 m^2) planted on lines, the line was 2 meters long, the spaces between them were 20 centimeters, and a distance of 1 meter was left between one experimental unit and another. The fertilization process was carried out with urea two batches of a source of nitrogen, according to the fertilizer recommendation, 120 kg N ha^{-1}, the first two weeks after planting and the second after one month and a half of the first batch. Additionally, Triple superphosphate fertilizer at a rate of 80 kg P2O5 ha-1 (46% P) was applied prior to planting. Eighty kg of potassium were applied per hectare before planting (Al-Abedi, 2011).

In the branching stage, spraying process carried out by seaweed extract (Super Fifty) produced by the Turkish company Agressenses. As for the bio-fertilizer consisting of (Azospirillium, Pseudomonas, Bacillus) and produced by the Iranian company, the spraying process was carried out in elongation stage, and spraying operations were carried out in morning using a sprayer Dorsal, a spreader, was added to increase spraying efficiency and ensure complete wetness of the plants.

The data was statistically evaluated in the program (GenStat) in accordance with the methodology. The mathematical means compared by using L.S.D. test and a 5% level of probability (Al-Rawi, and Khalaf-Allah, 2000).

Samples taken from (0-30) cm depth from the field's soil from each replicate and different places, and they were mixed to form a composite random sample to represent the field of the experiment before planting (Table 1).

Table 1. physical, and chemical properties of field soils before planting.

Attributes		Values	Units
pH		7.2	
E.C.		1.9	Desimines M^{-1}
CEC		20.9	Centimeter (+) kg $^{-1}$
Re. N		21	mg kg $^{-1}$ of soil
Re. P		8.5	mg kg $^{-1}$ of soil
Re. K		164	mg kg $^{-1}$ of soil
Analysis of	sand	165	
minute volumes	gluten	455	Kg kg $^{-1}$
	Clay	390	
Soil texture		Clay loam	

RESULTS AND DISCUSSION

Spikes number m^2 (spike m^2): The data in Table (2) show that spraying higher amounts of nano-seaweed extract has a substantial effect. which increased spikes number per m^2. Maximum average density of 412.60 spikes per square meter was found at the greatest concentration (E2). Compared to the control treatment, which recorded a lowest average of 344 spikes m^2. The reason for increase may be because plants treated with seaweed extract were characterized by good vegetative growth, and this may be due to their content of essential nutrients for growth, such as nitrogen, which has a wide range in increasing the vital activities in the plant (Osman *et al*., 2010), and therefore will increase It is absorbed by growth of the plant, which is indicative of on increased growth and led to an increase in spikes number. This result is consistent with (Leila *et al*., 2018).

The results in Table (2) indicate a significant increase spikes number per m^2 with the increase in concentrations of bio-fertilizer spraying compared to comparison treatment. The highest concentration (F2) gave an average of 400.60 spikes m^2, while comparison treatment recorded a lowest average number of spikes of 350 spikes m2. The increase number of spikes per m^2 may be attributed to role of bacteria that make up the bio-fertilizer in improving vegetative growth, encouraging the absorption of nutrients, stimulating enzymatic reactions, and revitalizing vital processes. The result is consistent with (Wali *et al.*, 2018).

There were no statistically significant deviations when the two elements of the study were combined in spikes number (Table 2).

Table 2. Effect of the spraying seaweed extract, nano-bio fertilizer, and their interaction on spikes number of m^2 (spike m^2).

Seaweed extract (E)	Bio-fertilizer (F)			Mean (E)
	F_0	F_1	F_2	
E_0	339.90	340.30	351.90	344.00
E_1	348.70	397.00	398.40	381.40
E_2	361.40	424.70	451.70	412.60
Mean (F)	350.00	387.30	400.60	
L.S.D $_{0.05}$	E	F	F × E	
	26.75	25.33	N.S	

***Grains number in spike (grains spikes^{-1})*:** Table (3) showed that spray concentration E2 of seaweed nano-particle extract was significantly superior to all other spray levels, which had an average of 45.36 grains per spike, more than any other, as opposed to the E0 control group's lowest result of 35.40 grains spike-1. The ingredients in the extract from growth regulators could be to blame, amino acids, and nutrients and their role in increasing process of photosynthesis and increasing its outputs and its transmission from the source to the downstream, which is represented by the spike, it increased the amount of grains.

Increasing the dosage of nano-biological fertilizer sprayed on the crops led to a corresponding rise in the spikes on the grains, as shown in Table 3. The highest concentration (F2) recorded the highest average for this characteristic, amounting to 44.00 grains of spike^{-1}, when compared to the no-spray treatment, which resulted in the fewest spikes per unit of grain (34.04 spikes spike-1), a statistically significant difference can be seen. Some of the key enzymes in a plant's metabolic pathways may have been stimulated by bio-fertilizer, which could explain the observed increase. which caused the number of grains in the spike to rise, and these results agreed with what was reached (Ali and Al-Jutherdi, 2011).

Table 3. Effect of spraying seaweed extract, nano-bio fertilizer, and their interaction on grains number (grains spikes^{-1}).

Seaweed extract (E)	Bio-fertilizer (F)			Mean (E)
	F_0	F_1	F_2	
E_0	33.67	36.00	36.53	35.40
E_1	32.67	42.33	42.87	39.29
E_2	35.80	47.67	52.60	45.36
Mean (F)	34.04	42.00	44.00	
L.S.D $_{0.05}$	E	F	F × E	
	2.38	1.41	2.72	

As for the interaction, the data of Table (3) indicated the superiority of the combination (E2×F2), represented by the higher concentration of seaweed extract The combination (E1F0) resulted in the lowest average grains number of spikes (32.67 spikes -1) whereas the higher concentration of bio-fertilizer resulted in the greatest mean (52.60 grains of spike-1).

1000 grains Weight (g): Table 4 shows that there were no statistically significant variations in 1000 grains weight between spray concentrations of nano-extract.

While the results in Table (4) indicated that the no-spray treatment was significantly superior in 1000 grains weight and gave highest average at 34.61 g, while the highest concentration (F2) gave a lowest average, which amounted to 32.90 g, perhaps the reason for the increase in the comparison treatment is due to small number of its grains per spike (Table 3) led to an increase weight of the grain. This result differed from what was obtained (Shahbazi *et al.*, 2015). As for the interaction, a significant increase was found for the combination (E0×F0), This is represented by the control treatment for both components; it produced the highest average weight at 1000 grains, 36.33 g, while the combination (E2F0) produced the lowest average weight, 31.33 g. (Table 4).

Table 4. Effect of the spraying seaweed extract, nano-bio fertilizer and their interaction on 1000 grains weight (g).

Seaweed extract (E)	Bio-fertilizer (F)			Mean €
	F_0	F_1	F_2	
E_0	36.33	32.00	32.33	33.56
E_1	36.17	31.67	33.40	33.74
E_2	31.33	32.67	33.00	32.33
Mean (F)	34.61	32.11	32.91	
L.S.D $_{0.05}$	E	F	F × E	
	N.S	1.28	3.35	

Total grain yield (kg ha^{-1}): Table (5) showed, the maximum concentration (E2) of spraying with seaweed extract significantly increased overall grain production, and it gave the highest 4253 kg ha^{-1}, compared to the lowest value when the comparison treatment (E0), which amounted to 3837 kg ha^{-1}. This was reflected positively and increase in grain yield (Al-Hasany *et al.*,2019). Spraying with a higher concentration of seaweed extract may increase grain yield since the same concentration increases both the number of spikes per square meter of land (Table 2) and grains quantity in spike (Table 3). Table (5) showed a spraying by nano-biological fertilizer of highest concentration (F2) was significantly superior in total of grain yield with a highest average of 4327 kg ha^{-1} compared to no-spray treatment, which gave lowest average for this characteristic amounted to 3606 kg ha^{-1}. This could be due to the bacterial components of the compost, which increased both: spikes number of m2 (Table 2), and grains quantity per spike (Table 3), resulting in a higher overall grain production, as predicted by the experiment (Faraj, 2012).

As for interaction, Table (5) indicated superiority of combination (E2×F2), represented by the higher concentration of both the extract and the bio-fertilizer, and it gave a highest average grain yield of 4589 kg ha^{-1}. In comparison, the combination (E1×F0) recorded the lowest average, the capacity reached 3422 kg ha^{-1}.

Table 5. Effect of the spraying, seaweed extract, nano-bio fertilizer and their interaction on total grain yield (kg ha^{-1}).

Seaweed extract (E)	Bio-fertilizer (F)			Mean (E)
	F_0	F_1	F_2	
E_0	3424	4014	4074	3837
E_1	3422	4333	4318	4025
E_2	3972	4198	4589	4253
Mean (F)	3606	4182	4327	
L.S.D $_{0.05}$	E	F	F × E	
	189.00	187.20	265.30	

***Conclusions*:** The study showed: Spraying with 1 ml l-1 of seaweed extract produced the most spikes per m2, grains per spike, and overall grain production. Spraying versus not spraying 1000 grains. Bio-fertilizer at 5 g l-1 improved spikes per m2, grains per spike, and grain yield. The interaction indicated significant differences in grains per spike, 1000 grain weight, and total grain yield.

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***Conflict of interest*:** Mohammed A. R. Aljaberi and another authors declares no conflicts of interest

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